CALIFORNIA STATE SCIENCE FAIR
2009 PROJECT SUMMARY

Name(s)

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Project Number

S0215

Project Title

The Effect of Attack Angle and Airfoil Design on the Output of Small Wind Turbines in Low Reynolds Flow

Abstract

Objectives/Goals

The purpose of this study is to optimize the airfoil design and attack angle of the blades of small wind turbines in low Reynolds flow. Wind turbines of this size are ideal for rooftop settings in the suburban environment and the data can be magnified to optimize larger wind turbines. Optimization is sought through both the theoretical and the empirical.

Methods/Materials

I started by taking two common, yet distinct, airfoil designs for small wind turbines the A18 (more cambered and 7.3 percent thickness)and the SD7062(less cambered and 14 percent thickness), and subjecting these airfoils to varying attack angles. I tested each airfoil twice at 0, 15, 30, 45, 60 and 75 degrees at a high speed and a low speed. I built my airfoils by hot wiring foam blocks then sanding the airfoils to create a smooth surface. These airfoil blades were then attached to a free spinning shaft to reduce frictional forces. Wind was provided by an array of fans so as to produce a constant airflow over the blades at all times.

Results

The rotation at 60-degrees was optimal, but it was only optimal with an initial energy input. After an assisted start, the vector of the wind changed allowing it to develop high speeds with limited drag along the rotational axis. Additionally, the output of the A18 Airfoil at the optimal attack angle increased by only 12 percent from the low wind speed to the high wind speed, while the SD7062's output increased by nearly 40 percent. Overall, the A18 airfoil performed better than the SD7062 for all tests.

Conclusions/Discussion

The difference between the SD7062 and the A18 at different wind speeds suggests a threshold. The frictional drag on the blades remained relatively constant as the wind speeds increased but the pressure drag on the A18 greatly increased. The A18 is significantly more cambered and thus experiences turbulent flow at a lower Reynolds number. While providing more lift at lower speeds, the camber of the A18 limits its performance in higher speeds. The SD7062 seemingly maintains laminar flow throughout. Additionally, there appears to be an exponential relationship between output and attack angle, until a point where output collapses. Finally, this project has shown that twist is necessary. By my calculations, for the A18 at 60 degrees, the tips were going 13 m/s faster than the bases. Thus the tips must have a larger attack angle as the vector of the wind drastically changes.

Summary Statement

This project seeks to optimize small wind turbines for low wind speeds by varying attack angle and airfoil design.

Help Received

My dad bought me all the supplies and my mom did all the drilling